

## 3.7 Groundwater

This section of the Klamath Facilities Removal Environmental Impact Statement/ Environmental Impact Report (EIS/EIR) describes the changes in groundwater levels and availability that would be caused by the Proposed Action and alternatives.

### 3.7.1 Area of Analysis

This EIS/EIR's area of analysis, or "project area," for groundwater as related to the Klamath Hydroelectric Settlement Agreement (KHSA) includes the area within 2.5 miles upstream of J.C. Boyle, Copco 1, Copco 2, and Iron Gate Reservoirs. The project area lies within Klamath County, Oregon, and Siskiyou County, California. The project area for the Klamath Basin Restoration Agreement (KBRA) with respect to groundwater is the Klamath basin upstream of Copco 1 Dam. This is the area covered by a United States Geological Survey (USGS)-Oregon Water Resources Department (WRD) groundwater model designed to determine effects on groundwater from pumping water for irrigation purposes. No model exists for areas below Copco 1 Dam. Groundwater issues, such as changes in groundwater levels or recharge, are described in this section, 3.7 Groundwater. Issues related to geology are described in Section 3.11, Geology, Soils, and Geologic Hazards.

### 3.7.2 Regulatory Framework

Groundwater resources within the area of analysis are regulated by the state and local laws listed below.

#### 3.7.2.1 State Authorities and Regulations

- California Water Code (CWC §10750, §10753.7, §1702, §1706, §1727, §1736, and §1810) (California, State of)
- California Assembly Bill 3030 (CWC §10750 et seq.)
- California Senate Bill 1938 (Sections 10753.4 and 10795.4 of, to amend and renumber Sections 10753.7, 10753.8, and 10753.9 of, and to add Sections 10753.1 and 10753.7)
- Oregon Revised Statutes (Chapters 536 through 541) (Oregon, State of)
- California Department of Water Resources (DWR) Bulletin 118 (DWR 2003)

#### 3.7.2.2 Local Authorities and Regulations

- Siskiyou County Code (Title 3, Chapter 19) (Siskiyou County)

### 3.7.3 Existing Conditions/Affected Environment

#### 3.7.3.1 Groundwater Basin Hydrology Description

##### Regional Groundwater Conditions

The project area has few wells that completely characterize groundwater conditions. Gannett et al. 2010 completed the most recent and comprehensive attempt to estimate the

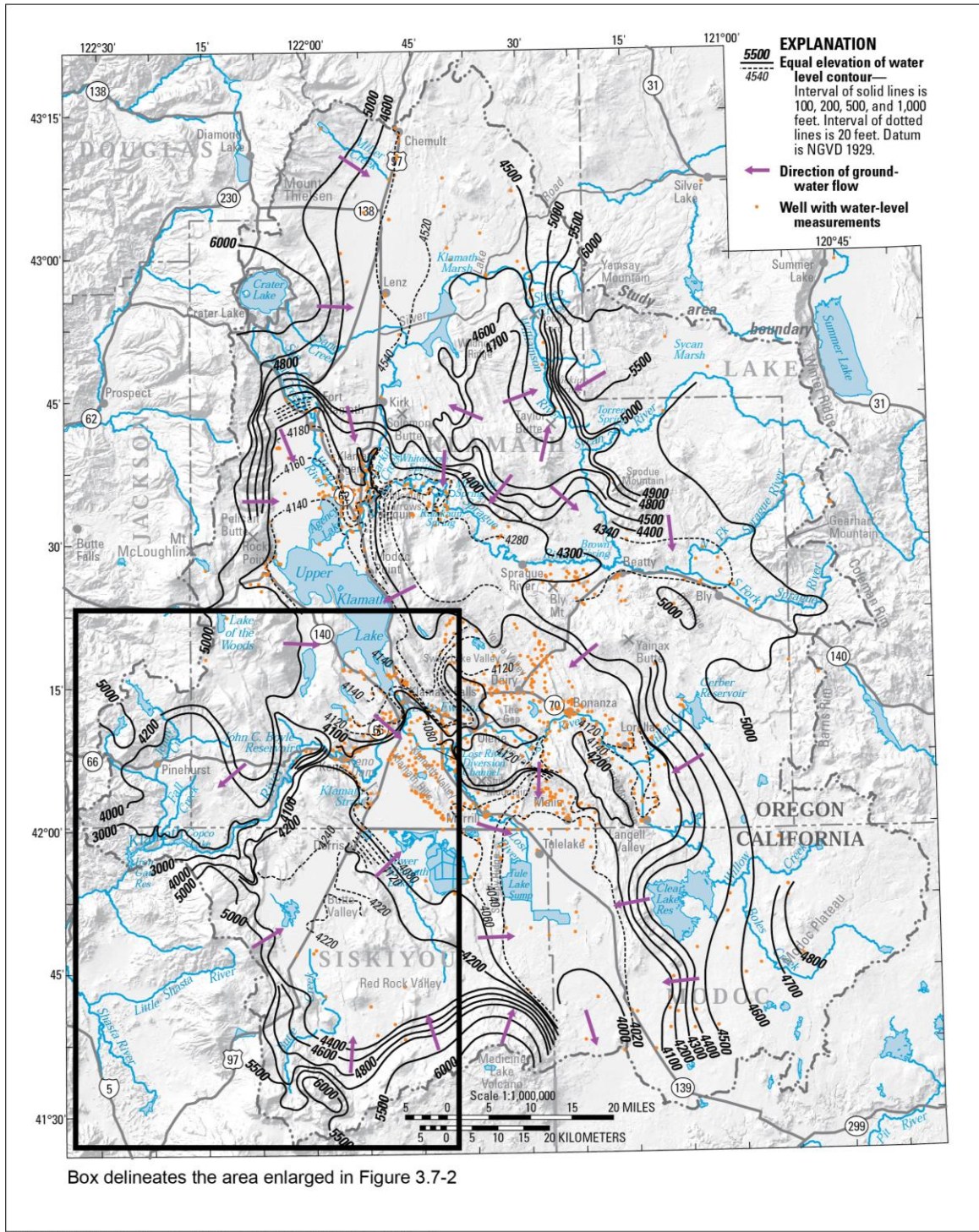
water level gradients and flow patterns within the project area upstream and downstream of the four dam sites. Figures 3.7-1 and 3.7-2 show a generalized groundwater flow map for the Upper Klamath Basin and portions of the Lower Klamath Basin. Figure 3.7-2 suggests that the regional groundwater flow patterns along the Klamath River downstream of Keno Dam are generally from the higher elevations (upland areas, mountain ranges, hills, etc.) toward the Klamath River, and from Keno Dam toward Iron Gate Dam (United States Department of the Interior [DOI] 2011a). Figure 3.7-2 suggests a groundwater divide exists under Keno Dam. The groundwater level contours suggest that the groundwater system above Keno Dam is isolated from the groundwater system below Keno Dam.

The Lead Agencies reviewed the area around the reservoirs on USGS topographic 7½-minute quadrangle maps (Iron Gate and Copco Quadrangles in California; Spencer Creek and Chicken Hills Quadrangles in Oregon) (DOI 2011a). Numerous springs, where groundwater discharges to the surface, are shown surrounding Iron Gate Reservoir. These springs occur at elevations from less than 50 to more than 300 feet (ft) above the reservoir level (DOI 2011a). The maps also show springs around Copco Reservoir. These springs are similarly less than 50 to more than 800 feet above the reservoir level (DOI 2011a).

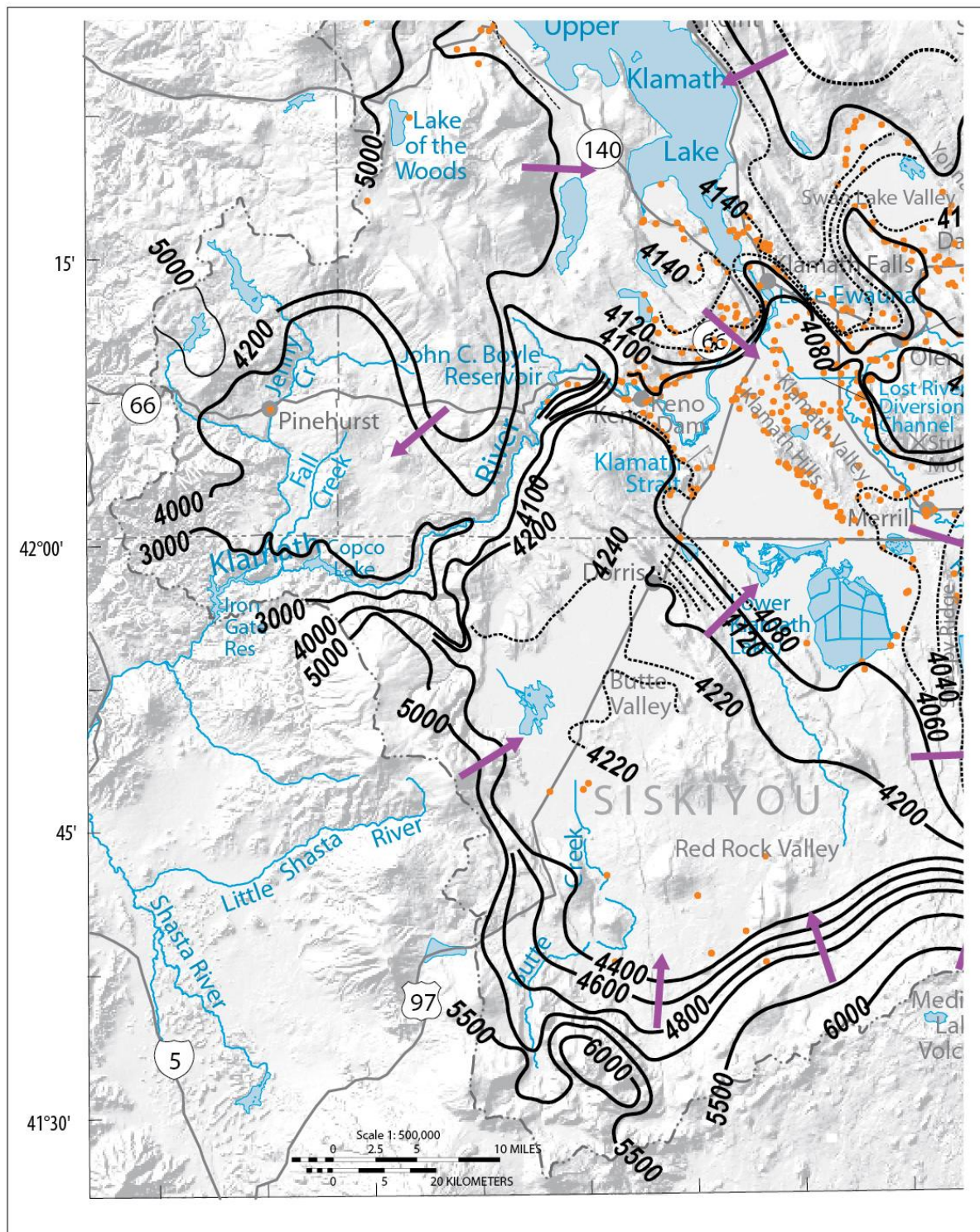
The USGS mapping shows a number of the small drainages that empty into Copco Reservoir have a spring at the headwater of the drainage. The maps show very few springs in the vicinity of J.C. Boyle Reservoir, and those that are shown are only a few tens of feet above the reservoir level (DOI 2011a). However, many of the small drainages that empty into J.C. Boyle Reservoir have a spring at the headwater of the drainage (e.g., Spencer Creek (Gannett et al. 2010)). The presence of springs in the area suggests local groundwater systems, and possibly a regional groundwater system, that are not receiving water directly from the reservoirs (DOI 2011a). That is, the water discharging from the springs is not thought to be reservoir water (DOI 2011a).

The flows from the springs and the location of the springs could be influenced indirectly by the presence of a reservoir because the reservoir could create higher groundwater levels adjacent to the reservoir. These higher groundwater levels could cause groundwater levels to be increased as compared to the condition where the reservoir was not in place. These increased groundwater levels could rise to the ground surface and affect the location of a spring and the volume of water discharging from the spring. The level of hydraulic connection between the reservoirs and the spring systems is not known (DOI 2011a).

A spring complex about one mile below J.C. Boyle Dam contributes substantial flow to the river (Gannett et al. 2010). The water discharging at this site may be originating from the local groundwater system. The flows could also be influenced by seepage from the reservoir that is flowing around or under the dam and coming to the surface at the spring site. It is likely that the flows from this spring complex are influenced by both the local groundwater system as well as leakage from the reservoir (DOI 2011a).



**Figure 3.7-1. Generalized Groundwater Potentiometric Surface Contour Map and Groundwater Flow Directions in the Upper Klamath Basin [after Gannett et al. 2010]**



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**Figure 3.7-2. Enlarged Portion of the Generalized Groundwater Potentiometric Surface Contour Map and Flow Directions for the Areas Around J.C. Boyle, Copco, and Iron Gate Reservoirs [after Gannett et al. 2010]**

### **Sources of Groundwater in Project Area**

Groundwater in the project area is likely fed by the infiltration and subsequent percolation of precipitation through the surface materials to the bedrock units. As Figures 3.7-1 and 3.7-2 show, at a regional scale, groundwater appears to flow into the project area near the four dams from upland areas toward the Klamath River and the reservoirs. The figures show an apparent groundwater divide in the area just upstream of J.C. Boyle/Keno Impoundment. These figures also show the regional trends in groundwater elevations and flow paths. Where groundwater levels are above the river and reservoir elevations, it is generally assumed that groundwater levels in the vicinity of the reservoirs are supported by the regional groundwater system more so than by reservoir leakage. However wells immediately adjacent (potentially extending up to a mile from the reservoirs under certain conditions) to the reservoirs are more likely influenced by reservoir leakage where such leakage exists.

Local groundwater in the project area is also fed by groundwater underflow from these upgradient areas. In the absence of barriers to vertical flow, surface water infiltration is a common source of recharge to groundwater systems. Rivers, lakes and other surface water bodies are common sources of site specific infiltration recharge. Aerial precipitation is more of a dispersed, wide extent source of infiltration recharge. Given a regional groundwater flow direction toward the river and reservoirs in the project area, reaches are more likely receiving water from the groundwater systems than they are losing water to the groundwater systems, while reservoirs are more likely to lose water to the groundwater (DOI 2011a). However, there are conditions where the reservoirs could be gaining water from the groundwater system(s) (DOI 2011a). The lack of data from groundwater wells in the area makes a more specific characterization of groundwater sources in the project area difficult.

### **Groundwater Sinks in Project Area**

In areas where surface water levels are lower than the adjacent groundwater level, groundwater can discharge to the surface water (e.g., rivers, streams, and reservoirs). This would be called a groundwater “sink” because groundwater flows towards it and is lost from the groundwater system. Gannett et al. (2010) estimates that groundwater adjacent to the Klamath River discharges to the river in the project area. An average discharge of 190 cfs of groundwater for the reach from Keno Dam to downstream of the J.C. Boyle Powerhouse and 92 cfs for the reach from there downstream to Iron Gate Dam is estimated (Gannett et al. 2010). These estimates are calculated for the length of each of these reaches based on gage data and changes in reservoir storage. These estimates may include some ungaged tributary inflows.

Groundwater pumping is also a typical process in the project area where water is removed from the groundwater system. In the project area, groundwater is pumped to the surface for domestic use and irrigation. Most domestic wells around the reservoirs are likely seasonal residences (i.e., owner’s official address is different than the well location address) and are not expected to be a major groundwater sink in the project area (DOI 2011a). Average well yields in Siskiyou County, California are just over 19 gpm while in Klamath County, Oregon the average yield is just over 22 gpm (DOI 2011a). Based on

completion dates on well logs for Siskiyou County, an average of five new wells per year have been installed in the project area since 1963. In Klamath County the average is about three new wells per year since 1976, including the area around Keno and Keno Dam, Oregon (DOI 2011a).

A large groundwater flow system exists in the Upper Klamath Basin (Gannett et al. 2010). Groundwater is recharged in areas in the Cascade Range and upland areas surrounding the basin. Groundwater flows from these areas toward the interior of the basin and subbasins (Figure 3.7-1). Many of the streams in the interior of the basin are at least partially fed by groundwater discharge (Gannett et al. 2010). Some streams are fed predominately by groundwater (i.e., baseflow) at a consistent rate throughout the year.

Groundwater is used in the Upper Basin to irrigate agricultural land as well as for domestic, industrial, and municipal purposes. Groundwater is used as a primary source of irrigation water where surface water is not available and also as a supplemental source when surface supplies are limited (Gannett et al. 2010).

Groundwater levels vary in response to both climatic and pumping conditions. Climatic variations can vary the groundwater level by five feet within the basin. The typical drawdown and recovery cycles caused by groundwater pumping can be from one to ten feet. Groundwater use in the Upper Basin has increased by 50 percent since 2001 primarily in the area surrounding Reclamation's Klamath Project. The increase in pumping has resulted in groundwater levels dropping 10 to 15 feet in portions of this area between 2001 and 2004 (Gannett et al. 2010).

#### **Local Groundwater Conditions**

The California DWR *Bulletin 118 – Update 2003, California's Groundwater*, delineates 515 groundwater basins and subbasins throughout the state. The area of analysis for the Proposed Action and alternatives does not fall within one of these delineated basins. The area is defined as a "groundwater source area" by the California DWR. A "groundwater source area" is "rocks that are significant in terms of being a local groundwater sources, but do not fit the [typical] category of basin or subbasin" (DWR 2003). The Klamath River from the Oregon-California Stateline to downstream from Iron Gate Dam is a predominantly non-alluvial river flowing through mountainous terrain. Downstream from the Iron Gate Dam, and for most of the river's length to the Pacific Ocean, the river maintains a relatively steep, high-energy, coarse-grained channel frequently confined by bedrock. Section 3.11, Geology, Soils, and Geologic Hazards, of this document describes project area geology in more detail.

Well information was obtained and reviewed from the databases of both the Oregon WRD and the California DWR to identify well logs for known domestic and irrigation wells within several miles upstream and downstream of the Four Facilities. Roughly 83 percent of the logs (300 out of 360 logs) had sufficient information to be able to identify with a reasonable amount of certainty the locations of these wells in relation to the reservoirs. Of the 300 logs for which reasonable coordinate data could be

determined, only 63 wells were within 2.5 miles of one or more of the three reservoirs, 25 near Iron Gate, 22 near Copco 1 and 2, and 16 near J.C. Boyle (DOI 2011a).

Using the local topography, reservoir bathymetry, and lithologic descriptions on the well logs, representative cross-sections across various spans of the reservoirs were generated such that each cross-section intersected at least one known well location. The cross-section for J.C. Boyle is presented below, and cross sections for Copco 1 and 2 and Iron Gate are presented in Appendix K. Each cross-section displays the topography, water surface elevation of the reservoir, well log ID, abbreviated well log lithology, and the static water level in the well. The water-bearing units in each well are presented in summary tables for each reservoir.

The discussions of potential or possible impacts to the local wells from the Proposed Action are predicated on the concept that in order to be impacted, the water-bearing unit that each well is tapping must be hydraulically connected to the reservoir – either by having the water-bearing unit exposed to the surface (i.e., daylight) within the reservoir walls or being hydraulically connected to the reservoir through a series of permeable layers between the reservoir and the water-bearing unit.

The potential for impacts to the wells is further predicated on the relative elevation differences between the static water level in the well(s) and the water surface elevation of the reservoir. Specifically, if the water-bearing unit being tapped by any given well is in hydraulic connection with a reservoir, then the static water level in the well should be similar or close to the water surface elevation in the reservoir. If the static water level is higher or lower than the reservoir level, and the water-bearing unit is not exposed along the reservoir walls, then it is likely that the water-bearing unit is reflecting a regional or local aquifer system influence in addition to, or in place of, the reservoir. If the water-bearing unit itself is entirely above the reservoir water levels, or is substantially deeper (more than three or four intervening impermeable units) than the lowest portion of the reservoir, then it would be unlikely that the water-bearing unit would be in hydraulic connection with the reservoir. It should be noted that the static water level in a well can vary from year to year based on preceding hydrologic conditions (i.e., climatic cycles, wet years vs. dry years).

### **J.C. Boyle Reservoir**

The bedrock surrounding and underlying the J.C. Boyle Reservoir is principally composed of moderately well bedded to massive, moderately well-consolidated volcanic rocks of the High Cascade Geomorphic Province. Lava flows dominate the landscape and geologic strata and form many of the ridges above the reservoir. In the downstream portion of the reservoir (downstream from the Highway 66 bridge) young lava flows line the sides of the reservoir (DOI 2011a). Section 3.11, Geology, Soils, and Geologic Hazards, provides additional geologic information.

The Oregon WRD well database identifies 50 wells within 2.5 miles of the J.C. Boyle Reservoir (Oregon WRD 2011). Sixteen of these 50 wells were able to be located geographically based on well addresses recorded on the drill logs or by comparing the

well log information to ownership parcel data supplied by Klamath County. Ten of those 16 wells were shallow Oregon Department of Transportation borings near bridge footings. Figure 3.7-3 shows the locations of the wells that could be located. The construction details for these wells are outlined in Appendix K.

Three cross-sections that intersected at least one of the six wells were developed. Figure 3.7-3 shows the locations of these cross-sections. Figures 3.7-4 and 3.7-5 show the cross-sections. The well parameters used to develop the cross-sections are summarized in Table 3.7-1.

The data in Table 3.7-1 suggests that the water-bearing volcanic units of the High Cascade are deeper than the bottom elevation of the reservoir (i.e., the pre-reservoir river bed) in wells 10059 and 51633. The static water level for each well is 50 to 100 ft below the bottom of the reservoir. The top of the water bearing layer and the static water level in well 14002 are similar to the elevation of the river bed (DOI 2011a). Therefore, the reservoir level is unlikely to affect these wells.

The lateral extent, homogeneity/inhomogeneity, and degree of fracturing, of the volcanic deposits in the region are variable. Some degree of hydraulic connectivity exists between the reservoir and water bearing strata near the reservoir which allows downward migration of reservoir water. There may also be a zone of similar horizontal hydraulic connectivity around the reservoir. The extent and degree of connectivity is uncertain based on the limited well data. Both wells 10059 and 14002 have significant amounts of clay recorded on the logs at depths between the top of their water bearing units and the equivalent depth of the old river bed that probably inhibits or significantly reduces the vertical migration of infiltration water from the reservoir. The extents of these clay units are uncertain (DOI 2011a).

Comparison of the elevations of the static water levels in the six wells near J.C. Boyle reservoir shows that two wells downstream of the dam (13628, 14002) have static water levels 20 to 40 feet below the pre-dam river bed elevation (at the dam site); the two wells (10514, 10059) furthest away from the reservoir (4,721 feet and 5,518 feet from the reservoir) have static water level elevations nearly 100 feet below the pre-dam upstream river bed elevation; and the two wells near the shore of the reservoir have static water level elevations 20 to 30 feet below the pre-dam river bed elevation at the dam site. The static water level elevations in the wells furthest from the reservoir are near or below the static water level elevations for the wells closer to the reservoir. No clear determination of any trends in vertical head gradients can be drawn from the data of these six wells (DOI 2011a).

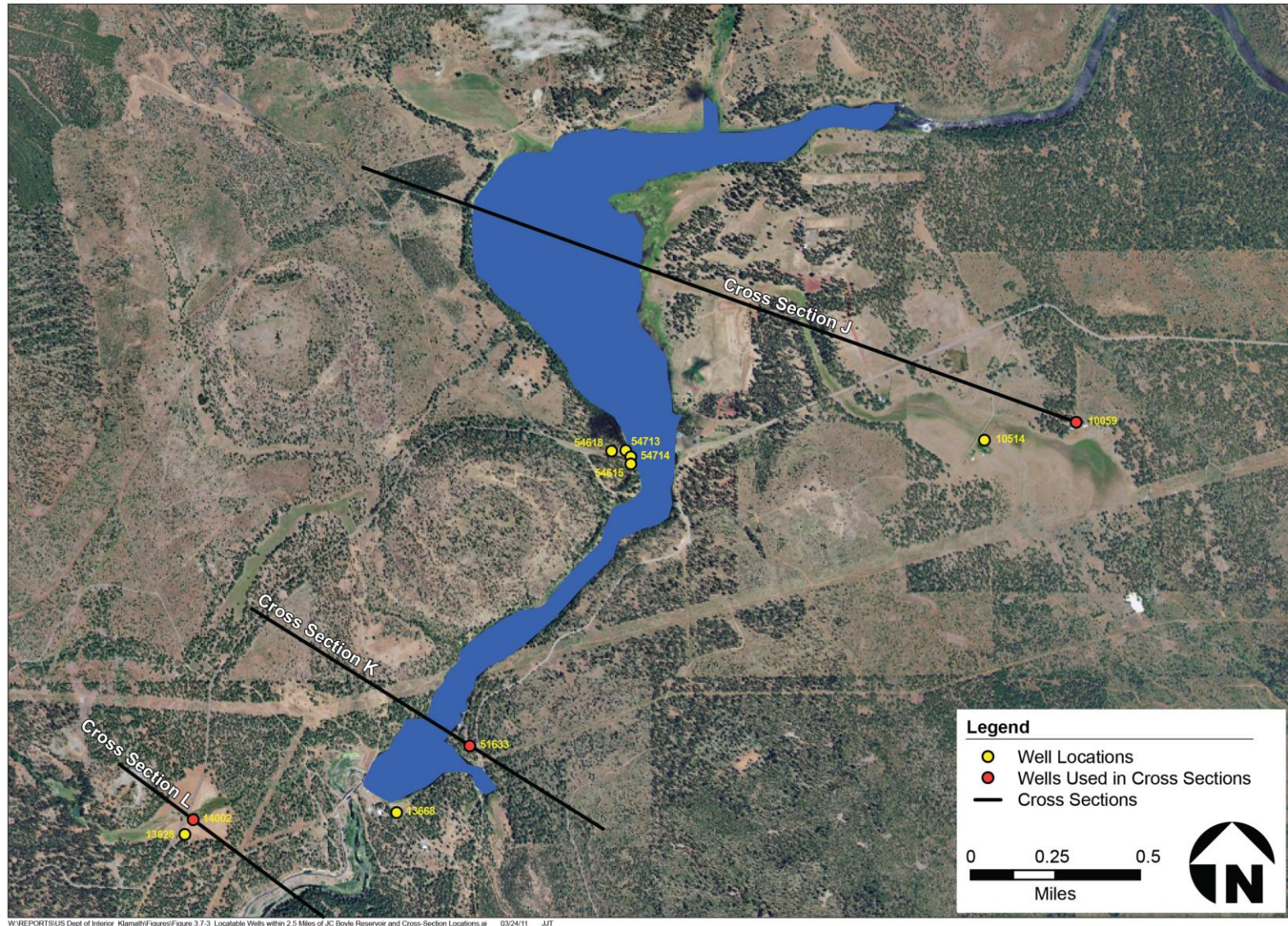


Figure 3.7-3. Locatable Wells within 2.5 Miles of J.C. Boyle Reservoir and Cross-Section Locations

**Table 3.7-1. Well Construction Information for Wells<sup>1</sup> within 2.5 Miles of J.C. Boyle Reservoir<sup>2</sup>**

Well ID <sup>3</sup>	Drill Date	Well Diameter (in)	Depth to top of perforated zone or bottom of surface casing in an open well (ft)	Depth to bottom of perforated zone (ft)	Depth of Well (ft)	Depth to 1st Water (ft)	Pumping Rate (gpm)	Depth to Static Water (ft)	Located on Cross-Section	Static Water Elevation (ft)	Water-Bearing Unit and Top Elevation (ft)
10059	6/29/1990	6	159 <sup>4</sup>	Open	281	77	12	222	J	3,686	Brown lava and clay from 203 to 223 ft bgs interspersed with black rock from 212 to 215 ft bgs, and gray rock and clay, and gray rock from 223 to 281 ft bgs with bubbly brown lava from 257 to 280 ft bgs; Elevation 3,705 ft
14002	8/10/1988	6	99 <sup>4</sup>	Open	238	181	25	178	L	3,698	Hard gray volcanic rock from 181 to 238 ft bgs; Elevation 3,695 ft
51633	10/19/2006	6	280 <sup>4</sup>	Open	315	126	55	126	K	3,701	Gray and brown basalt from 126 to 315 ft bgs interspersed with hard gray basalt, broken and fractured zones, and two ash layers; Elevation 3,700 ft

Source: DOI 2011a, DOI 2010.

Notes:

<sup>1</sup>Well list does not include Oregon Department of Transportation boreholes used for bridge footings.

<sup>2</sup>Reservoir stage is 3,787 ft AMSL; river bed elevation at the dam is 3,720 ft AMSL.

<sup>3</sup>All wells listed as domestic supply wells.

<sup>4</sup>Depth to the bottom of the surface casing or sanitary seal in holes/wells that are openKey:

Key:

AMSL: above mean sea level

bgs: below ground surface

in: inches

ft: feet

gpm: gallons per minute

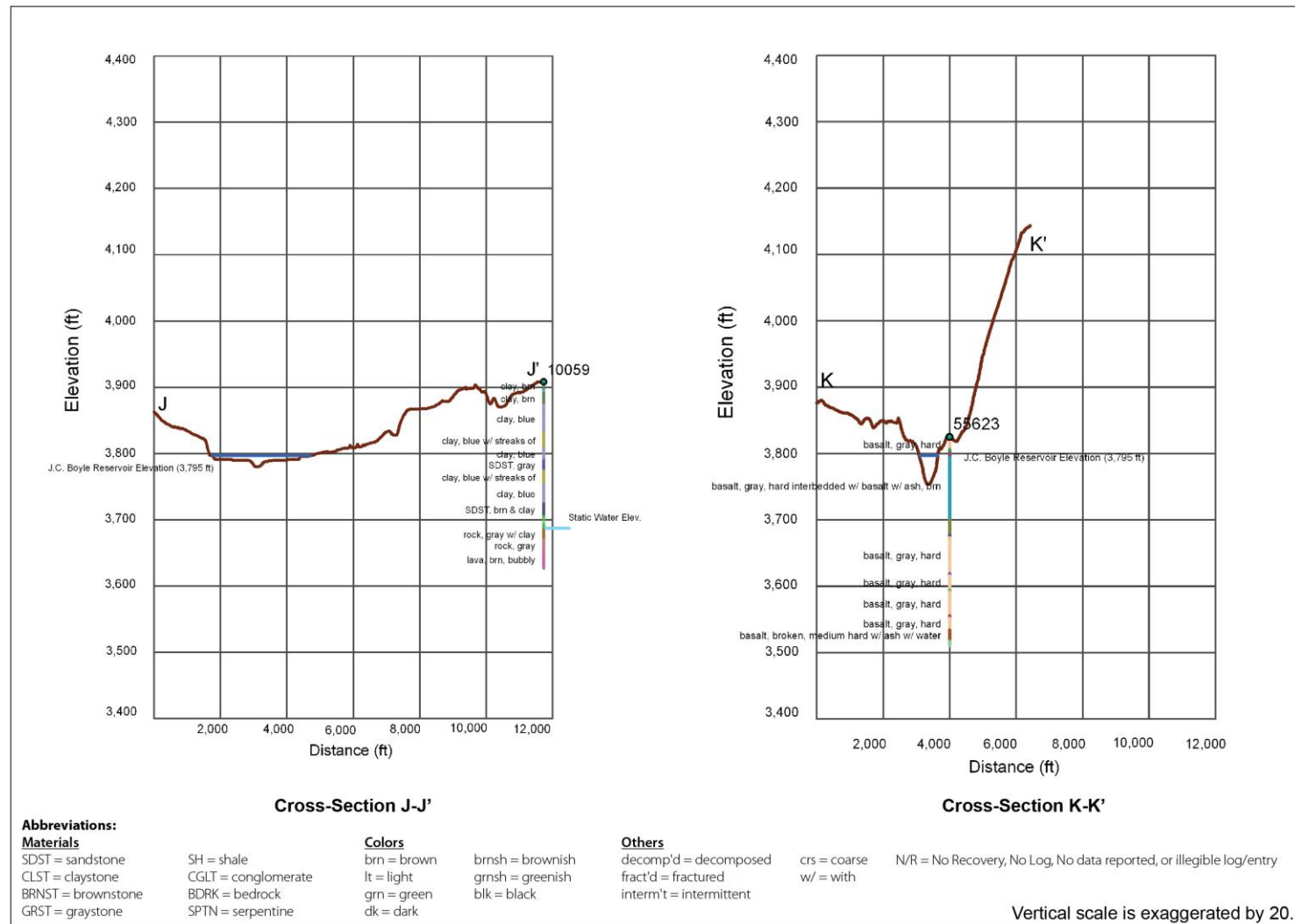
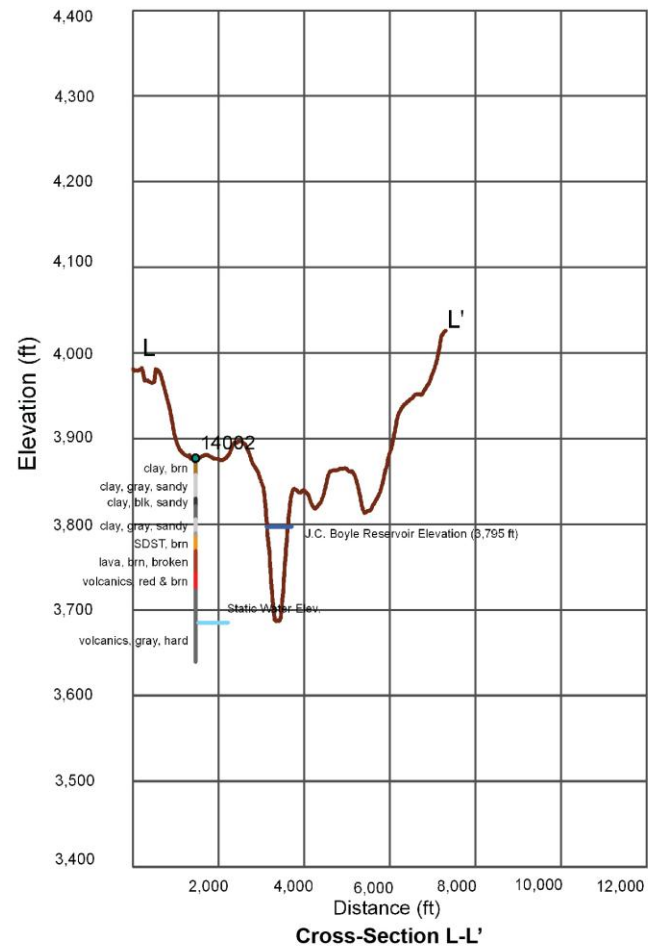


Figure 3.7-4. J.C. Boyle Reservoir Cross-Sections J and K



**Figure 3.7-5. J.C. Boyle Reservoir Cross-Section L**

### **Copco 1 and Copco 2 Reservoirs**

As described in Section 3.11, Geology, Soils, and Geologic Hazards, Copco Lake including the smaller impoundment at Copco 2 Dam, sits at the divide between the Western Cascade and the High Cascade geomorphic provinces. The Western Cascade is faulted and intruded by basaltic dikes and its composition of lower and higher permeable stratified rocks results in discrete aquifer units. The relationship between groundwater flow in and between the High Cascade and Western Cascade is complicated and not well understood but the groundwater utilized in the vicinity of Copco Lake is likely contained in the permeable units of the High Cascade or upper water bearing units of the eastern dipping Western Cascade based upon the generally shallow depth of known groundwater wells. The Western Cascade strata have the potential to contain geothermal reservoirs where capped by the High Cascade lava flows (Hammond 1983).

The identification of wells in the vicinity of the Copco Reservoirs followed the same method as for the J.C. Boyle Reservoir. The California DWR well database identifies 22 wells within 2.5 miles of the Copco Reservoirs. Figures and tables showing the locations and construction details of the 22 identified wells and the five cross-sections that were developed are provided in Appendix K.

The data for the wells in the cross-sections indicate that the water-bearing units and static water levels are above the bottom of the reservoir. All the wells near the Copco Reservoirs, with the exception of one well, have static water levels that are below the reservoir stage but above the river bed elevation at the dam site. Similarly, all the wells except one have elevations for the top of the water bearing unit below the reservoir stage and above the river bed elevation at the dam site. The two exceptions are two different wells. The top of the water bearing formation was not identified on the log for some wells. In this case, the elevation at which water was first encountered in the drilling is used as a substitute for the top of the water bearing unit.

The average static water level for all wells less than 300 feet from the reservoir is 2,591 feet while the average static water level for all wells greater than 400 feet from the reservoir is 2,680 feet (DOI 2011a). These levels suggest that there is downward groundwater flow near the reservoir (i.e., groundwater is flowing down toward the reservoir). Because groundwater is flowing toward the reservoir, this information suggests that the water level in the reservoir does not have a significant lateral influence on groundwater levels in the area around J.C. Boyle reservoir (DOI 2011a).

### **Iron Gate Reservoir**

Iron Gate Reservoir overlies the volcanic units of the Western Cascade which like Copco 1 Reservoir have been faulted and intruded by basaltic dikes (Hammond 1983). The relationship between groundwater flow in the units of the Western Cascade is complicated and not well understood. Specific groundwater well data provides the best understanding of the occurrence of groundwater in the vicinity of Iron Gate Reservoir.

The identification of wells in the vicinity of Iron Gate Reservoir followed the same method as for the J.C. Boyle, Copco 1, and Copco 2 Reservoirs. The California DWR well database identifies 25 wells within 2.5 miles of the Iron Gate Reservoir. Figures and tables showing the locations and construction details of the 25 identified wells and the five cross-sections that were developed are provided in Appendix K.

The well data shows that the static water level (when recorded) is above the reservoir stage with only two exceptions (wells 781723, 99834). The static water level for all the wells is also above the elevation of the river bed at the dam site with only one exception (781723). The data in Appendix K shows that the estimated elevation of the top of the water bearing unit (recorded on 13 of the 25 logs) is above the reservoir stage in 10 of the 13 wells. The top of the water bearing unit is between the reservoir stage and the reservoir bottom in two wells. The top of the water bearing unit is below the reservoir bottom in only one well (781723).

Wells further away from Iron Gate Reservoir have higher static water levels and generally higher top of water bearing unit elevations than wells closer to the reservoir. These elevations indicate groundwater flow direction is towards the reservoir in agreement with the regional groundwater gradients (Gannett et al, 2010). Wells within 2,000 feet of the reservoir have static water levels very close or above to the reservoir stage (one exception, well 334387) indicating a potential flow direction toward the reservoir. The current well dataset cannot determine conclusively whether Iron Gate Reservoir has any vertically downward or horizontal seepage (DOI 2011a).

### **3.7.4 Environmental Consequences**

The section analyzes the environmental consequences on groundwater from implementation of the Proposed Action or its alternatives. Effects to groundwater quality are not expected because groundwater discharges to surface water in the majority of the area. Impacts to water quality are discussed in detail in Section 3.2, Water Quality.

#### **3.7.4.1 Environmental Effects Determination Methodology**

The method for this analysis was to compare the effects of the Proposed Action and alternatives to the existing conditions. This analysis used the groundwater information presented in Section 3.7.3 to evaluate potential effects on existing wells and on groundwater's influence on surface water resources in the project area.

#### **3.7.4.2 Significance Criteria**

For the purposes of this EIS/EIR, impacts would be significant if they would result in the following:

- Lowering of the local groundwater table level so the production rate of pre-existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted.

- Substantially interfering with groundwater levels or groundwater recharge so there would be changes to the groundwater/surface water interaction that would adversely affect surface water conditions or related resources.

Land subsidence caused by aquifer collapse can be caused by many processes such as the dewatering of fine grained materials (i.e., clays) or collapse of the structure of an aquifer (i.e., through dissolution or piping). Although land subsidence as a result of changes in groundwater levels is a common significance criterion, it is not considered in this EIS/EIR given that land subsidence would not be an effect of the Proposed Action or alternatives because water levels would not be lowered in areas of substantial clay deposits and the rock types of the aquifer are not susceptible to collapse in the area of analysis.

#### **3.7.4.3 Effects Determinations**

##### **Alternative 1: No Action/No Project**

*Under the No Action/No Project Alternative, there would be no change in project dam and associated facility operations and no impacts on groundwater resources.* Under the No Action/No Project Alternative, J. C. Boyle, Copco 1, Copco 2, and Iron Gate Dams and their associated facilities would remain in place and be operated similarly as they have been during historical operations. Therefore, the No Action/No Project Alternative would not change the elevation of surface water in the reservoirs outside of historical ranges. Groundwater levels would be expected to remain consistent with historic values. **Therefore, no changes from existing conditions relative to the elevation of the groundwater table in the vicinity of the reservoirs would be expected.**

*Under the No Action/No Project Alternative, there could be increased groundwater storage.* Activities associated with the No Action/No Project Alternative include certain resource management actions that are currently approved and ongoing, and which would continue to be implemented. Actions that could affect groundwater resources include Agency Lake and Barnes Ranches. These actions would provide new storage to store additional surface water supplies. In some years, when water is available, groundwater use could decrease. Stored surface water would also increase seepage into underlying groundwater basins. **This would be a beneficial effect to groundwater resources.**

##### **Alternative 2: Full Facilities Removal of Four Dams (the Proposed Action)**

*Under the Proposed Action, groundwater levels in existing wells adjacent to the reservoirs could decline in response to the drop in surface water elevation when the reservoirs are removed.* The water-bearing units from which most of the existing domestic or irrigation wells pumps are either below the elevation of the original river channel, are exposed along reservoir walls, or are above the reservoir stage. There is limited data to fully characterize the degree of hydraulic connection between these water bearing units and the reservoirs.

Some of the water-bearing units that are tapped by existing domestic or irrigation wells are above the reservoir elevation and are at elevations similar to those of mapped springs. These springs are likely fed by the same water-bearing units supplying the wells and

neither would likely be significantly impacted by the removal of the reservoirs. The primary impact that would be expected could be a drop in the groundwater levels in these higher elevation water bearing units as the reservoirs drain and new local groundwater levels are established relative to the river elevation.

A number of existing domestic or irrigation wells lie close to the reservoir shorelines (well within the 2.5 miles.) These wells may be influenced by the dropping reservoir water levels when directly or indirectly connected to the reservoir. However, all but three of the shoreline wells tap water-bearing units with elevations below the bottom of the reservoir. The degree of impact will be controlled by the degree of hydraulic connectivity between the reservoirs and the water bearing units below and adjacent to the reservoirs. The degree of connectivity between the reservoirs and water bearing units below and adjacent to the reservoirs is uncertain.

As noted previously, there are existing (and locatable) domestic or irrigation wells that pump from water-bearing units that may be directly connected to the reservoirs. Therefore, changes in reservoirs water levels might directly affect the groundwater level in the wells. Other wells in the vicinity of these three wells access deeper water-bearing units.

In general, domestic or irrigation wells with static water levels that are close to the elevation of the pre-dam river channel will, most likely, not be impacted by the removal of the reservoirs as the river already is a base line for these wells. Similarly, wells with static groundwater levels above the pre-dam river bed elevation, but below current reservoir stages, could experience groundwater level declines down to pre-dam river bed elevations as the river is re-established. The potential impacts at specific wells will depend upon local hydrogeologic conditions at the well site as well as the well construction characteristics. Hydrogeology between well locations conditions can vary widely between sites.

Fish hatchery operations will continue at the Iron Gate Hatchery for eight years following removal of the Iron Gate Dam. After eight years, hatchery production will continue, but may be at an alternate site. Under the KHSRA, PacifiCorp is responsible for evaluating hatchery production options that do not rely on the current Iron Gate Hatchery water supply. Such options could include use of groundwater, surface water, or water reuse technologies. PacifiCorp is also responsible for proposing and implementing a post-Iron Gate Dam Hatchery Mitigation Plan (Hatchery Plan) to provide continued hatchery production for eight years after the removal of Iron Gate Dam; and this Hatchery Plan would be developed with information from PacifiCorp's evaluation. However, PacifiCorp is not required to propose a Hatchery Plan until six months following an affirmative Secretarial Determination. The Lead Agencies do not currently know what PacifiCorp will propose in the Hatchery Plan and are unlikely to know unless there is an affirmative Secretarial Determination. An impact analysis of a hatchery production option that does not rely on the current Iron Gate water supply would be purely speculative at this point. Therefore, the potential environmental effects of implementing

a hatchery production option that does not rely on the current Iron Gate water supply are not analyzed in this EIS/EIR.

There are existing domestic and irrigation groundwater wells that could not be located reliably based on the information in the Oregon WRD or California DWR databases. In addition to the non-locatable wells in the databases, there are likely other existing wells in the vicinity of the reservoirs. The real estate information presented in the Dam Removal Real Estate Evaluation Report prepared by the DOI in 2011 lists 1,467 potentially impacted parcels near the Copco and Iron Gate reservoirs. Of those 1,467 parcels, 12% (176 parcels) are listed as improved and 88% (1,291 parcels) are shown as vacant (DOI 2011b). The extent of improvements on the 12% of parcels is not known. However, it is possible that improvements may have included installation of a groundwater well for domestic supplies. The number of improved parcels near the J.C. Boyle reservoir is not known. Therefore, there could be additional domestic or irrigation wells in water-bearing units that intercept the reservoirs. **A decline in groundwater levels at nearby wells would be a significant impact, but implementation of mitigation measure GW-1 would reduce this impact to less than significant.**

*The Proposed Action could cause a reduction in groundwater discharge to the Klamath River.* Removing the dam and eliminating the reservoir could result in less percolation of surface water to the underlying groundwater aquifer due to removal of the water body. However, as discussed in Section 3.7.3 Affected Environment, the reservoirs generally lie within rock valleys where this recharge is expected to be low. Gannett et. al. 2010 concluded that the Klamath River reaches in the project area are gaining reaches (i.e., groundwater discharges to the stream). This assessment, and characteristics of the rock surrounding the reservoirs, suggest that any surface water that may have infiltrated to groundwater systems under the reservoir would likely discharge back to the river just downstream of the impoundment.

The Proposed Action would result in the same relative volume of water flowing through the project area in the Klamath River. The timing of river's hydrograph would be modified to improve fish habitat. Under current conditions, water is retained in the reservoirs to maximize hydropower production by filling and keeping the reservoirs as full as possible; however, the stored volume in the reservoirs does not vary substantially from one time period to another to act as a buffer to flows going down the river. Under the Proposed Action, the water in the river would remain in the river through the project area. **The Proposed Action's impacts on groundwater recharge and the resulting groundwater/surface water interaction would be less than significant.**

*The Proposed Action will require the relocation of the City of Yreka water supply pipeline.* The existing water supply pipeline for the City of Yreka passes under the Iron Gate Reservoir and will have to be relocated prior to the decommissioning of the dam to prevent damage from deconstruction activities or increased water velocities once the reservoir has been drawn down. The pipeline would be suspended from a pipe bridge across the river near its current location. The water supply utilized by the City will not

change, and none of the construction activities are anticipated to interact with or impact existing groundwater supplies or require groundwater supplies to complete the construction. **The relocation of the Yreka water supply pipeline would result in no change in existing conditions of groundwater supplies.**

*Under the Proposed Action, recreational facilities currently located on the banks of the existing reservoirs will be removed following drawdown.* The existing recreational facilities provide camping and boating access for recreational users of the reservoirs. Once the reservoirs are drawn down, these facilities will be removed. The removal of the recreational facilities would not impact groundwater or groundwater recharge. **The removal of the recreational facilities would result in no change in existing conditions of groundwater resources.**

#### **Keno Transfer**

*Implementation of the Keno Transfer could cause adverse effects to local groundwater.* The Keno Transfer is a transfer of title for the Keno Facility from PacifiCorp to the DOI. There will be no changes in facility operations. This transfer would not result in the generation of impacts to groundwater compared with existing facility operations. Following transfer of title, DOI would operate Keno in compliance with applicable law and would provide water levels upstream of Keno Dam for diversion and canal maintenance consistent with agreements and historic practice (KHSa Section 7.5.4). **Therefore, the implementation of the Keno Transfer would result in no change from existing conditions.**

#### **East and West Side Facilities**

*Decommissioning the East and West Side Facilities could have adverse effects to groundwater resources.* Decommissioning of the East and West Side canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSa will redirect water flows currently diverted at Link River Dam into the two canals, back in to Link River. Following decommissioning of the facilities there will be no change in outflow from Upper Klamath Lake or inflow into Lake Ewauna. Groundwater recharge in the area is not expected to change. **The decommissioning of the East and West Side facilities would result in no change in existing conditions of groundwater resources.**

#### **KBRA**

The KBRA, which is a component of the Proposed Action, encompasses several programs that could affect groundwater, including:

- Water Diversion Limitations
- On-Project Plan
- Water Use Retirement Program
- Interim Flow and Lake Level Program
- Emergency Response Plan

Water Diversion Limitations and the On-Project Plan

*The Water Diversion Limitations program could reduce irrigation water in the driest years.* The Water Diversion Limitations program (KBRA Section 15.1) would reduce the availability of surface water for irrigation on Reclamation's Klamath Project to 100,000 acre feet less than the demand in the driest years to protect mainstem flows. These limitations are intended to increase water availability for fisheries purposes. Reducing surface water diversions to Reclamation's Klamath Project irrigators could result in increased reliance on groundwater substitution during the driest years. Groundwater pumping could occur with emergency wells located on Reclamation's Klamath Project. These wells can only be pumped under a drought declaration. Irrigators typically utilize gravity delivered surface water when available. An increased reliance on groundwater could affect groundwater levels in the pumped aquifer and reduce groundwater inflow into the Klamath River and its tributaries. Groundwater substitution could also affect wells that tap into the same water-bearing units (Gannett et. al. 2010). Therefore, the KBRA includes provisions that would require monitoring of pumping at existing wells, the monitoring of groundwater levels in the pumped aquifer, and the monitoring of springs affected by drops in groundwater levels. Additionally the KBRA prohibits groundwater use within Reclamation's Klamath Project boundaries that results in a reduction in flow of a spring by more than six percent to avoid impacts on groundwater discharge into the Klamath River and its tributaries that would reduce the availability of thermal refugia for fish in these water bodies. The KBRA identifies springs to be monitored and protected as those along Upper Klamath Lake, the Wood River subbasin, Spring Creek on the Williamson River, the Klamath River downstream to Copco 1 Dam, Shovel Creek, and Spencer Creek. Appendix E-2 of the KBRA includes a work plan for investigation and monitoring of the groundwater resources of the Upper Klamath Basin.

With implementation of the KBRA, groundwater investigation and monitoring would occur and the results would be incorporated into the On-Project Plan (KBRA Section 15.2). In support of this groundwater investigation and monitoring effort, the USGS is developing a groundwater model planned for completion in 2011 that will be utilized to assess the effects of groundwater use in the basin and identify any adverse changes in groundwater levels (Gannett 2011). The On-Project Plan would include a plan for the use of groundwater, actions by managers to remedy any adverse impacts identified by groundwater investigations or monitoring, and includes a prohibition on adverse impacts on groundwater sources. A fund for remedying adverse impacts due to groundwater use is identified in KBRA Appendix C-2. Implementation of the On-Project Plan and Water Diversion Limitations program has the potential to generate localized short-term adverse effects on groundwater through the increased use of groundwater to replace surface water deliveries. These effects would be reduced through the implementation of groundwater monitoring and pumping restrictions triggered by any observed adverse effects on groundwater levels. The geographic separation between actions proposed under this program and the hydroelectric facility removal actions analyzed above reduce any potential for groundwater improvements generated by this program to contribute to groundwater effects generated by facility removal. **In the long-term implementation of the On-Project Plan (KBRA Section 15.2) and the Water Diversion Plan (KBRA**

**Section 15.2.4) would be expected to benefit groundwater resources by protecting them from overuse (through provisions prohibiting adverse impacts to groundwater, where none currently exist). Implementation of the On-Project Plan and Water Diversion Plan will require future environmental compliance as appropriate**

Water Use Retirement Program (WURP)

*Upland vegetation management under the WURP would increase inflow to Upper Klamath Lake.* The WURP is intended to permanently increase the flow of water into Upper Klamath Lake by 30,000 acre-feet per year to support restoration of fish populations (KBRA Section 16.2.2). Actions to increase inflow would include upland vegetation management of high water-use plants (i.e., juniper removal) to increase groundwater recharge. The geographic separation between actions proposed under this program and the hydroelectric facility removal actions analyzed above reduce any potential for groundwater improvements generated by this program to contribute to groundwater effects generated by facility removal. **Implementation of the WURP would benefit groundwater resources by increasing groundwater recharge through upland vegetation management. Implementation of the WURP will require future environmental compliance as appropriate.**

Interim Flow and Lake Level Program

*The purchase and lease of water under the Interim Flow and Lake Level Program would increase water for fisheries.* The Interim Flow and Lake Level Program (KBRA Section 20.4) would be an interim program of water purchase and lease to reduce surface water diversions and further the goals of the fisheries programs during the interim period prior to full implementation of the On-Project Allocation and WURP. Water purchase and lease agreements with a term greater than the interim period defined in KBRA Section 20.4.2 would be subject to a consistency requirement with the On-Project Plan. Reduced surface water diversions would not be expected to directly result in increased groundwater use given provisions developed to prevent adverse impacts to groundwater in the KBRA (Section 15.2.4). The geographic separation between actions proposed under this program and the hydroelectric facility removal actions analyzed above eliminate any potential for negative groundwater effects generated by this program contributing to groundwater effects generated by facility removal. **Implementation of the Interim Flow and Lake Level Program would result in less than significant impacts on groundwater resources in the short term, and would be expected to benefit groundwater resources in the long-term. Implementation of the Interim Flow and Lake Level program will require future environmental compliance as appropriate.**

Emergency Response Plan

*Implementation of an Emergency Response Plan could result in changes to groundwater following the failure of a Klamath Reclamation Project facility or dike on Upper Klamath Lake or Lake Ewauna.* The purpose of the plan is to prepare water managers for an emergency affecting the storage and delivery of water needed for KBRA implementation. The components of the Emergency Response Plan are described in Section 2.4.3.9 and

include potential emergency response measures and processes to implement emergency responses. Implementation of an Emergency Response Plan could potentially reduce emergency groundwater use following a facility or dike failure that limited surface water deliveries by shortening the duration of any surface water delivery interruption. The intent of this plan is to allow for continued storage and delivery of water according to KBRA commitments and would not affect the probability of facility or dike failure. Additionally, given the geographic separation between actions proposed under this program and the hydroelectric facility removal actions analyzed above, the Emergency Response Plan would not be expected to contribute to any changes in groundwater generated by the hydroelectric facility removal action. **Therefore, it is anticipated that implementation of the Emergency Response Plan would result in no change to existing conditions in groundwater resources. However, implementation of the Emergency Response Plan would likely help to reduce groundwater use due to a facility or dike failure which would be a beneficial effect to groundwater resources. Implementing the Emergency Response Plan will likely require the analysis of changes to flood risks in future environmental compliance investigations as appropriate.**

#### **Alternative 3: Partial Facilities Removal of Four Dams Alternative**

The groundwater impacts of the Partial Facilities Removal of Four Dams Alternative would be the same as for the Proposed Action.

#### **Keno Transfer**

The groundwater impacts of the Keno Facility Transfer under the Partial Facilities Removal of Four Dams Alternative would be the same as for the Proposed Action.

#### **East and West Side Facility Decommissioning**

The groundwater impacts of the East and West Side Facility Decommissioning under the Partial Facilities Removal of Four Dams Alternative would be the same as for the Proposed Action.

#### **KBRA**

The groundwater impacts of the KBRA under the Partial Facilities Removal of Four Dams Alternative would be the same as for the Proposed Action.

#### **Alternative 4: Fish Passage at Four Dams**

*Under the Fish Passage at Four Dams Alternative, surface water elevations in the reservoirs would not change and there would be no changes to the relative elevation of the groundwater table.* Under the Fish Passage at Four Dams Alternative, the J. C. Boyle, Copco 1, Copco 2, and Iron Gate Dams and Reservoirs would remain in place and water levels in the reservoirs would be similar to historical levels. Therefore, the Fish Passage at Four Dams Alternative would not change the elevation of surface water in the reservoirs outside of historical ranges. Therefore, no changes to the relative elevation of the groundwater table in the vicinity of the reservoirs would be expected. **There would be no groundwater impacts under the Fish Passage at Four Dams Alternative.**

**Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate**

Groundwater impacts associated with the removal of Copco 1 and Iron Gate would be the same as under the Proposed Action. Groundwater impacts at Copco 2 and J.C. Boyle would be the same as those described for the No Action/No Project Alternative.

**3.7.4.4 Mitigation Measures**

**Mitigation Measure by Consequences Summary**

*Mitigation Measure GW-1* – This mitigation measure provides for the deepening (or replacement) of an existing affected domestic or irrigation groundwater well so the groundwater production rate from the well is returned to conditions prior to implementation of the Proposed Action or its alternatives. This mitigation measure is intended to mitigate for potential impacts from the Proposed Project or its alternatives. Therefore, a preconstruction well survey will be conducted prior to implementation of the Proposed Project or its alternatives. This survey will measure water levels and pumping rates in existing domestic and irrigation wells. This information will form the basis of review for potential claimed damages following construction activities. Well owners not participating in this preconstruction survey will be required to provide adequate documentation showing a decrease in production from the well before and after construction conditions. The review of pre-construction data will be considered with respect to preceding hydrologic conditions (i.e., climatic cycles, wet year vs. dry year). This mitigation measure would also provide an interim supply of potable water for health and safety prior to the completion of the modifications to the affected well.

**Effectiveness of Mitigation in Reducing Consequences**

Implementation of mitigation measure GW-1 would ensure that affected groundwater wells are able to provide water supply benefits similar to those prior to implementation of the Proposed Action or its alternatives.

**Agency Responsible for Mitigation Implementation**

The Dam Removal Entity would be responsible for implementing mitigation measure GW-1.

**Remaining Significant Impacts**

Following implementation of mitigation measure GW-1, no significant adverse impacts associated with groundwater would be anticipated. If the amount of groundwater discharging to the Klamath River was reduced so adverse impacts on fish habitat or habitat for other aquatic species resulted, such impacts would be considered significant. The potential for such impacts and mitigation for them have been addressed in other relevant chapters of this EIS/EIR.

**Mitigation Measures Associated with Other Resource Areas**

*Mitigation measure REC-1* would develop new recreational facilities and access point along the newly formed river channel between J.C. Boyle Reservoir and Iron Gate Dam. Recreation facilities, such as campgrounds and boat ramps, currently located on the edge of the reservoir would need to be replaced in appropriate areas near the new river channel

once the reservoir is removed. Water supplies for these facilities would most likely be supplied through wells located on the new recreational sites. These wells would be replacing existing wells and water consumption is unlikely to increase as a result of replacing recreational facilities. **Therefore, impacts to groundwater as a result of implementing mitigation measure REC-1 would be less than significant.**

No other mitigation measures associated with other resource areas as described in this EIS/EIR would affect groundwater resources.

### 3.7.5 References

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